ARMY RESEARCH LABORATORY

Simulation for Technology Assessment System (STAS) Concept Demonstration

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13. ABSTRACT *(Maximum 200 words)*

Techonology for an individual soldier simulator interacting with a separate combat model simulation was demonstrated in February 1995. The demonstration showcased several ongoing U.S. Army Research Laboratory (ARL) research projects: the Simulation for Technology Assessment System (STAS) and Untethered Land Warrior (UTLW) projects from the Simulation Methodology Branch of the Advanced Simulation and High Performance Computing Directorate (ASHPC) and the Direct Fire Module (DFM) Combat Simulation from the Weapons Analysis Branch of the Weapons Technology Directorate (WTD). This memorandum describes the research technologies that were demonstrated.

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1. INTRODUCTION

In 1995, the U.S. Army Research Laboratory's (ARL's) Advanced Simulation and High Performance Computing Directorate (ASHPCD) and Weapons Technology Directorate (WTD) combined several research projects into an interactive demonstration. This real-time demonstration featured a combat scenario wherein a live soldier interacted with constructive entities on a virtual reality battlefield.

A unique feature of this demonstration was that the combat scenario was designed in real-time by a Generic Scenario Generator (GSG) system. In this system the scenario was described in a general manner which we call the Combat Model Independent Generic Scenario (CMIGS) format. This CMIGS description was then compiled into a form understood by a specific computer-generated forces application. Computer-controlled forces could then be placed and given orders within the simulated environment. These computer-generated forces then interacted with a live soldier who independently maneuvered and executed his own command decisions on the battlefield. The live soldier was presented with a three-dimensional (3D) virtual battlefield perspective via the ARL Stealth viewing system. The Direct Fire Module Map (DFM Map) application provided a real-time two-dimensional (2D) view of the battlefield. Distributed Interactive Simulation (DIS) protocol was used to couple each of these components together into a seamless, real-time, interactive simulation.

The scenario generator and DFM Map are part of the Simulation for Technology Assessment System (STAS). The interactive soldier system and ARL Stealth viewer are part of the Untethered Land Warrior (UTLW) research project. The computer-generated forces application was the Direct Fire Module (DFM) combat simulation. Subsequent sections of this report describe each of these major components in more detail as they pertain to the demonstration.

Figure 1 illustrates the architecture used in the demonstration.

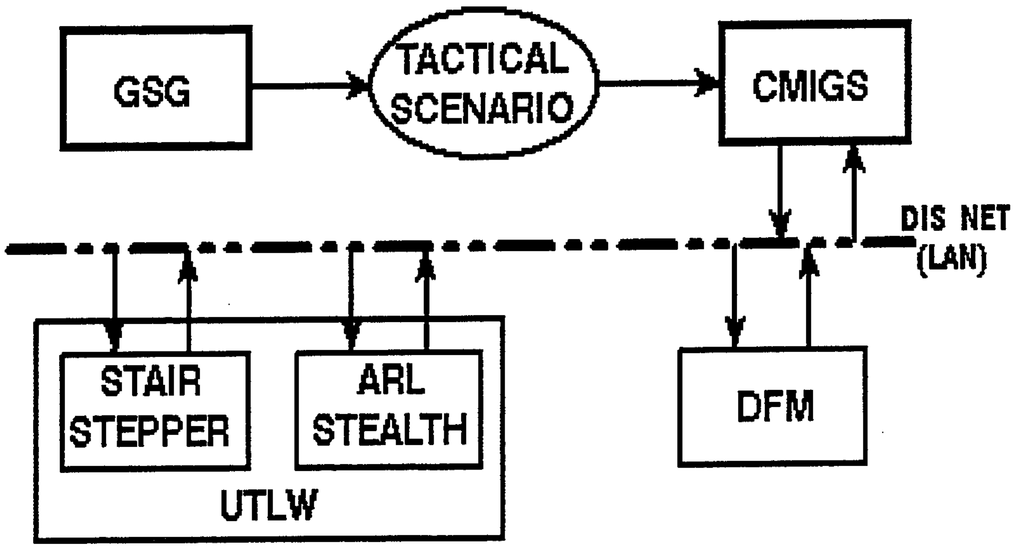

Figure 1. Demonstration Configuration

2. STAS

STAS is a prototype system designed to use simulation technology to assess the impact and interactions of new and proposed materiel, tactics, and technology on military systems and concepts (Smith, to be published). A major component of STAS is the Generic Scenario Generator (GSG). GSG is a collection of software programs that allow a user to rapidly define a generic combat scenario for use as input to a combat simulation. It uses an open-ended approach in that its output, or product, is a scenario description file that is independent of any specific combat simulation. The file is a complete and generic description of the combat scenario including specifications for the location and use of models that describe the

content, makeup, or behavior of particular elements in the scenario such as troops, vehicles, weapons, and even environmental conditions.

Another major component of STAS is the Scenario Translator. Its function is to translate the scenario description file into specific inputs targeted for a particular combat simulation. For demonstration purposes, the Scenario Translator was developed to generate scenario inputs for the DFM combat simulation. These inputs were generated by translating the scenario description file resulting from a user created scenario. See Figure 2.

GSG provides the capability to specify the scenario environment using predefined or user-definable terrain. Manmade, environmental, and meteorological conditions are optional aspects that can be added to the physical description of the environment. A unit editor is available for creating, selecting, and task organizing friendly and enemy forces within the scenario. Individual unit, equipment, and vehicle capabilities are definable and modifiable. Initial placement of units is currently done on a 2D overhead view of the terrain. Unit movement is prescribed by specifying routes comprised of way points for each unit.

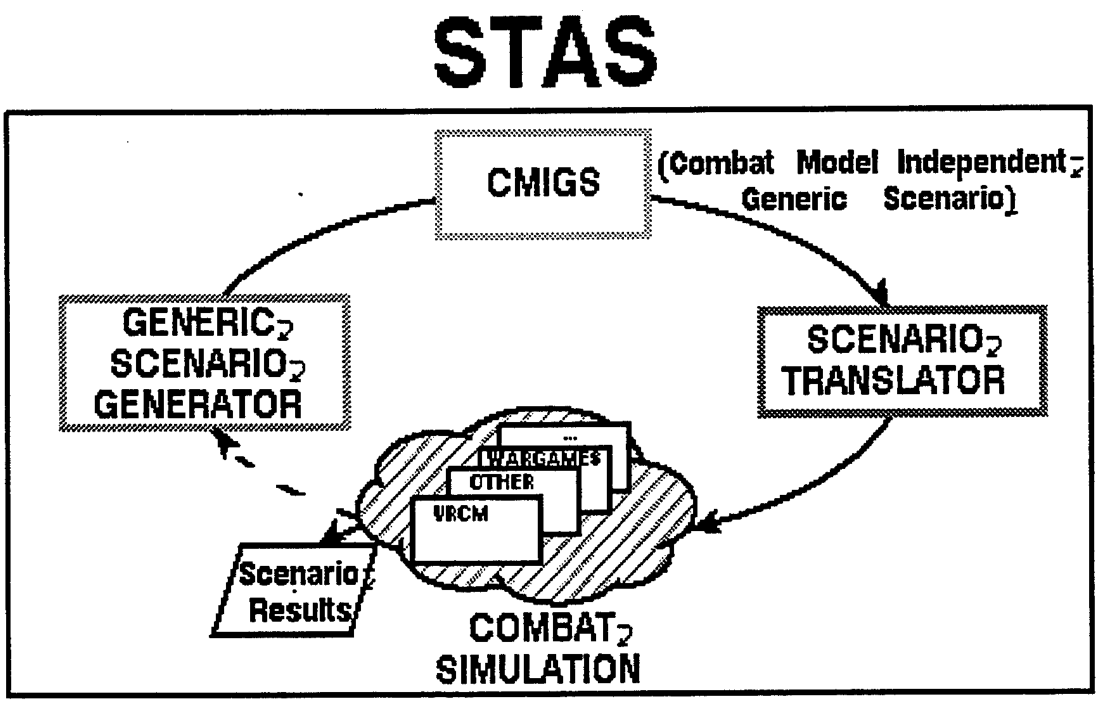

Figure 2. Simulation for Technology Assessment System

3. DEMONSTRATION DESCRIPTION

This section describes the STAS concept demonstration. Detailed descriptions on the STAS components used in the demo follow this section.

Physically, all the applications and devices were connected on the same local area ethernet network (Figure 1). On this link, applications communicated using DIS Protocol Data Units (PDUs). The Stair-Stepper and DFM passed each other DIS PDUs containing information relating to what their simulated entities were doing and where they were on the virtual battlefield. DFM Map and ARL Stealth monitored and digested this network traffic. These two applications used this information to visually display the battle as it developed (i.e., showing movements, weapons fired, detonations, damaged units, etc.). Before any of this could occur, the computer-generated forces had to be told what to do. This was done with the generic scenario generator (GSG) portion of STAS.

The demonstration started with GSG being used to choose which type of units would participate in the virtual battle. Combat units were selected in GSG from a database of unit descriptions. Unit selection occurred from within a GSG program called the "Unit Editor." Symbols (icons) for the selected units were visually displayed on a graphics terminal. These icons were then moved (via a mouse pointer) from the Unit Editor window and placed on the GSG map. (The GSG map is a STAS 2D map application displaying the virtual battlefield environment.) Once placed on the GSG map, units could then be given planned maneuver routes by selecting a series of objective points on the map. In this way, all units were placed and given objectives (if any) until the scenario description was completed. GSG placed the just-built scenario description into the CMIGS language format. Once the STAS user was satisfied with the scenario description, he/she then chose the combat model to execute it (e.g., in this case, DFM was selected).

Upon selecting DFM, the STAS Scenario Translator translated the CMIGS description into a format that DFM could understand. DFM then used this translated battle description to begin its real-time execution of the scenario. Units were placed on the virtual battlefield and the simulation commenced. The stair-stepper soldier had already been on the battlefield throughout the scenario building process. However, it was not until the STAS user executed DFM that the stair-

stepper soldier could observe computer-generated forces (if they were within sight) and interact with them in a limited fashion.

The stair-stepper soldier was able to interact with the DFM-controlled computer-generated forces by engaging these virtual threat forces with a simulated hand-held antitank weapon. As the soldier fired this weapon, a DIS Fire PDU was sent out on the network. DFM would receive a Fire PDU and "fly" the projectile (using a simple internal trajectory model) to determine what it hit. If a DFM-controlled, computer-generated tank was hit, then DFM used another internal model to determine the extent of any damage, and reflected the damage in subsequently sent Entity State PDUs. The demonstration ended after a predetermined amount of time.

4. DFM MAP

DFM Map is an X-Window-based data-driven display program used to provide a top-down 2D view of the battlefield during a DIS exercise. This program provides a clear, uncluttered, perspective of the entire battlefield. DFM Map uses DIS PDUs to drive its display. DIS events, gleaned primarily from Entity State, Fire, and Detonation PDUs are depicted through icon symbols representing units, weapons fire, and detonations. Markings described in Entity State PDUs are reflected through unit icon symbols. The map also provides the capability to change the area of view by zooming in or out by a preset factor or zooming to a window (an area outlined using the computer mouse) view. Figure 3 depicts DFM Map as it monitors a DIS exercise (Red 2 is shown firing and impacting a munition against Blue 7).

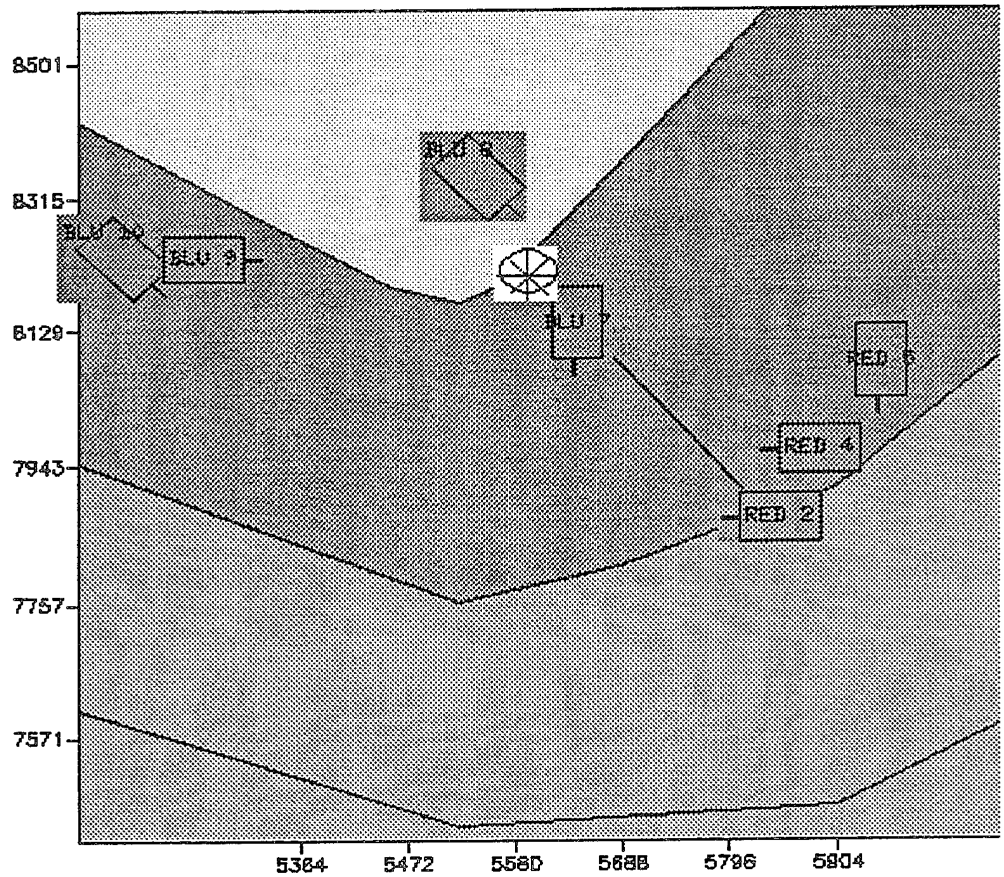

Figure 3. DFM Map Example Display

5. UNTETHERED LAND WARRIOR

The Untethered Land Warrior project is a research effort that is exploring methodologies needed to immerse an individual soldier in an environment composed of virtual, live, and constructive entities. An individual soldier, equipped with a portable computer, helmet-mounted heads-up display, Global Positioning System (GPS) locator, and body tracking sensors, will be free to move about a real environment that is augmented with computer-generated and virtual forces. These forces, and other DIS events, will be displayed through heads-up-display goggles. The soldier's movements and body position will be tracked through the GPS

system and body sensors. The portable computer will maintain the DIS "state" of the individual soldier and send out soldier-initiated DIS events through appropriate PDUs.

The UTLW project will allow an individual soldier to fully interact with both the real and virtual environment and with all virtual and constructive forces. The soldier will be able to "kill" or damage the constructive and virtual forces, and likewise be "killed" or damaged by them.

For this demonstration, the UTLW used a commercially available stair-stepper to simulate moving through a virtual environment.

A tracker was used to monitor the head position of the soldier in order to update the UTLW's view of the environment as rendered by the ARL Stealth viewer. The ARL Stealth is an SGI Performer-based, 3D graphics rendering program that was used in the demo to depict the view of the virtual environment and all related DIS events. For the demo, the view depicted was "slaved" to the view of the UTLW soldier.

Figure 4 displays the demonstration UTLW configuration in use. The soldier is seen viewing the ARL Stealth display while traversing through the virtual environment via the stair-stepper.

Figure 4. The Demo UTLW Stair-Stepper Device in Use

6. THE DIRECT FIRE MODULE (DFM) COMBAT SIMULATION

DFM is a portion of a larger ARL program, sponsored by the Weapons Technology Directorate, called the "Variable Resolution Combat Model (VRCM) program" (Wald 1989). The focus of VRCM is on the modeling of a potentially large battlefield simultaneously at several different command levels (e.g., Division, Battalion, Platoon, etc.). Conceptually, VRCM is a hybrid of innovative theories and more traditional analysis methods used to move units, resolve combat, and model other aspects of combat. When opposing forces come within "direct fire" range of each other, DFM is one module that VRCM might employ to resolve the outcome of the battle. While DFM is designed to be a callable module within a larger system, it is also a stand-alone combat simulation.

DFM is an N-on-M, multiweapon per platform, stochastic combat simulation between heterogeneous forces. N-on-M means that there can be an unequal number of opposing forces. Multiweapon per platform means each entity can have a number of weapon systems. (For example, an infantry fighting vehicle might have a main gun, a coaxial machine gun, an anti-tank missile system, and possibly more weapon systems.) Heterogeneous forces refers to the fact that numerous types of vehicles or platforms can simultaneously participate in the simulation. Lastly, stochastic means that the simulation can be run in a Monte-Carlo fashion. That is, the same initial battle conditions are used to generate numerous different battles. Data is gathered from these battle replications. From these data statistical inferences can be drawn. For the demonstration, DFM ran just one replication which was slowed down to run in real-time.

DFM controls battlefield entities at the individual weapon system level. Larger units, which are comprised of numerous weapon systems, have to be separated into their individual systems in order for DFM to simulate them. For example, if a tank platoon is to be simulated, then instead of specifying a single tank platoon, each weapon system (tank) of that platoon must be specified. DFM controls everything an entity does. Entities can independently move, halt, search for targets, detect, engage, and disengage them. Munition flights are tracked, and if another entity is impacted, then the resulting damage is calculated (if the impacted entity is under DFM's control).

6.1 Terrain in DFM

DFM was designed to incorporate Variable Resolution Terrain (VRT); alternatively, it can network to a "terrain server," or simply read a static terrain database. VRT is a continuous mathematical function that can be used to model terrain. Its advantage is that, since it is a continuous mathematical function, it has infinite resolution and is differentiable (almost) everywhere (Wald 1992). This is an extremely useful feature when one requires "micro terrain" sections of the battlefield. Memory can be efficiently allocated for small "micro terrain" sections and freed once this high detail is no longer necessary. (Though this benefit comes at the penalty of computation time.) For purposes of the demonstration, VRT was not required, and in order to be compatible with the other applications in the simulation, DFM used the same static digitized terrain database as the other participants.

6.2 Modifiable Entity Capabilities in DFM.

DFM can be used as an evaluation tool for weapon system concepts. Basic weapon system entities are built in a way to make it relatively easy to swap different ammunition, weapons, engines, and other components. This can be accomplished without code modification.

More unpredictable modifications to entity capability can be achieved at a software engineering level by replacing subroutine calls. In this respect, DFM is designed in a structured, object based, and modular fashion to reduce the confusion created by making such changes. An example of one such late entry entity adaptation has been active protection. Active protection is a defensive weapon concept. An active protection component is co-located with the entity and attempts to intercept an attacking munition in order to damage, deflect, or destroy that munition - before it reaches the entity. One model that simulates an active protection system is ACTPRO (Wald 1994). DFM incorporates active protection by compiling the ACTPRO model in the form of a software function (subroutine) call.

Future plans for DFM are to incorporate "plug-and-play" capabilities into its design. This will conceptually allow DFM to call separate stand-alone programs (such as ACTPRO) that are external from DFM. A major advantage is that the separate model will not have to be interfaced at a functional (or subroutine) level. (This eliminates the need for software changes.) How to best implement "plug-and-play" is an ongoing investigation at ARL.

6.3 Special Modification for the Demonstration.

Special consideration was made for the individual soldier simulator (the stair-stepper device). Unfortunately, at this point in the UTLW project, there were no physical controls to elevate or depress the soldier's weapon. (A LAW II shoulder-launched rocket was the weapon used for the demo.) For this reason, the man-in-the-loop would almost certainly never hit a target (except perhaps by accident), since he had no control to superelevate his weapon to the correct target range. Furthermore, software controlling the stair-stepper did not keep track of where its fired munitions flew, and consequently could not issue a Detonation PDU when it impacted something.

A special module was added to DFM to overcome these temporary deficiencies in the following manner. When DFM detected a fire event from the stair-stepper, it first looked to see if the soldier was facing towards any potential targets. If not, then DFM reissued the Fire event with the launch vector field set to the maximum weapon range. If, on the other hand, the soldier was facing any potential targets, DFM then decided which target was in range and at the same time closest to the soldier's orientation (direction he was facing). If a target was so qualified, DFM used that target's range to calculate a fire control superelevation. Then DFM reissued the Fire event using this superelevation solution. The launch orientation was still set for the direction the soldier was facing. In this way, the soldier could hit any target in range (provided he was correctly aiming at it). Following the fire event, DFM kept track of where the round flew. Upon the munition striking another entity, or the terrain, DFM issued a Detonation PDU on behalf of the stair-stepper. (It should be noted that DIS protocol states that applications are responsible for sending messages (PDUs) to other simulations to inform them of any observable actions. Hence, DFM's counterfeiting the stair-steppers's identity in this way could be viewed as a mild departure from DIS protocol.)

The detonating munition triggered various things to happen in other demonstration applications. For instance, DFM Map would place a flashing "detonation" icon at the point of impact and draw a line from there back to the stair-stepper icon (in order to indicate that the stair-stepper was responsible for this detonation). The ARL Stealth application presented a visual detonation effect. DFM actuated a sound server to simulate the explosion. (Even though DFM sent out the Detonation PDU, the PDU was sent on behalf of the stair-stepper. Therefore DFM behaved as if it had no prior knowledge until it was notified of the detonation event.) DFM also evaluated where the detonation occurred, and, if one of its entities was struck, it conducted appropriate vulnerability assessment against that entity. (Which, in turn, might trigger the ARL Stealth to present further visual effects - depending on the resulting entity damage.)

7. CONCLUSION

The Simulation for Technology Assessment System has demonstrated its potential for use within a multiplatform distributed simulation environment containing both virtual (UTLW) and constructive (DFM) simulations. One of its greatest assets is its capability to create scenarios in a generic environment and have simulations execute and evaluate these scenarios. The Combat Model Independent Generic Scenario (CMIGS) language provides the means by which a number of simulations may utilize these scenarios. Currently, DFM is the only simulation with a CMIGS translator. It is hoped that in the future other simulations will have CMIGS translators.

Additional work is required to further explore and develop the concepts that were demonstrated. In STAS, the GSG needs expanded capabilities for creating and modifying scenarios and their respective elements (units, equipment, objectives, capabilities, physical environment, etc.). The CMIGS language needs further development in order to provide a descriptively richer environment. DFM should be used to continue investigating techniques to develop reconfigurable combat simulations that support variable resolution fidelity combat and physical models that can be dynamically interchanged with like models. STAS is a vehicle by which these technological challenges can be researched.

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ACRONYM LIST

ASHPCD	Advanced Simulation and High Performance Computing Directorate
ARL	U.S. Army Research Laboratory
CMIGS	Combat Model Independent Generic Scenario
DIS	Distributed Interactive Simulation
DFM	Direct Fire Module
GPS	Global Positioning System
GSG	Generic Scenario Generator
PDU	Protocol Data Unit
SGI	Silicon Graphics Incorporated
STAS	Simulation for Technology Assessment System
UTLW	Untethered Land Warrior
VRCM	Variable Resolution Combat Model
VRT	Variable Resolution Terrain
WTD	Weapons Technology Directorate

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